

CRASH DATA RESEARCH CENTER

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CALSPAN ON-SITE AMBULANCE CRASH INVESTIGATION

SCI CASE NO.: CA11026

VEHICLE: 2001 FORD F350 / MCCOY MILLER TYPE I AMBULANCE

LOCATION: WEST VIRGINIA

CRASH DATE: OCTOBER 2011

Contract No. DTNH22-07-C-00043

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The crash investigation process is an inexact science which requires that physical evidence such as skid marks, vehicular damage measurements, and occupant contact points are coupled with the investigator's expert knowledge and experience of vehicle dynamics and occupant kinematics in order to determine the pre-crash, crash, and post-crash movements of involved vehicles and occupants.

Because each crash is a unique sequence of events, generalized conclusions cannot be made concerning the crashworthiness performance of the involved vehicle(s) or their safety systems.

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CALSPAN ON-SITE AMBULANCE CRASH INVESTIGATION
SCI CASE NO.: CA11026
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LOCATION: WEST VIRGINIA
CRASH DATE: OCTOBER 2011

BACKGROUND

This on-site investigation focused on the intersection crash and subsequent rollover of a 2001 Ford F350 series chassis that was equipped with a McCoy Miller Type I ambulance body (**Figure 1**). The crash resulted in the death of a 53-year-old male patient. The Calspan Special Crash Investigations (SCI) team identified the crash through internet media reports on October 12, 2011. The Crash Investigation Division (CID) of the National Highway Traffic Safety Administration (NHTSA) directed the Calspan SCI team to initiate telephone follow-up on the same day. Specifics regarding the crash were obtained from the investigating law enforcement agency and the case was assigned for on-site investigation on October 13, 2011. The SCI team achieved cooperation with the parent ambulance agency, and the on-site portion of this investigation took place October 19-20, 2011. This consisted of the detailed inspection and documentation of the involved vehicles and crash site, with interviews of the driver, two of the Emergency Medical Services (EMS) crewmembers, the ambulance agency's administration, and the son of the deceased patient.



Figure 1: Involved ambulance at final rest (*image from a local news source*).

The 2001 Ford F350 McCoy Miller Type I ambulance was operating in an emergency mode (with its lights and siren activated) while transporting the 53-year-old male patient to a local hospital. En route to their destination, the ambulance entered an intersection and was struck on its left side by a 1997 Dodge Ram 2500 pickup truck. Despite efforts by the ambulance driver to maintain control of the vehicle, its left rear tire/wheel contacted a median curb and tripped the ambulance into a one-quarter turn rollover. At the time of the crash, the ambulance was occupied by a 33-year-old male driver, a 53-year-old female front right passenger, three EMS crewmembers, and the 53-year-old male patient. The EMS crewmembers included two 23-year-old males and a 50-year-old male Paramedic. All six occupants were transported to a local hospital. The driver, front right passenger, and three EMS crewmembers were treated and released by the emergency department on the same day. The 53-year-old obese male patient expired within hours of his arrival at the hospital.

SUMMARY

Crash Site

The crash occurred at the intersection of a multi-lane divided roadway with the one-way exit/entrance ramps to a limited access roadway during nighttime hours. Artificial illumination was provided by overhead roadway lighting. Weather conditions at the time of the crash included light rain with a temperature of 6.1 Celsius (43 Fahrenheit) degrees, 8 km/h (5 mph) westerly breeze, and 89% relative humidity. The roadway surfaces were wet bituminous (asphalt) for the intersection and the north, south, and east legs. The west leg of the intersection transitioned from an asphalt roadway to a concrete overpass over the limited access roadway at a distance 30 m (98.5 ft) from the intersection stop bar of the westbound travel lanes. The intersection itself was level for the east/west roadway, with negative superelevation to the south of -2.1%.



Figure 2: Eastbound trajectory view of the ambulance's travel path.

In the ambulance's eastbound direction of travel prior to the intersection, the asphalt roadway curved left with a downhill slope of -4.1% and superelevation of -3.1% (**Figure 2**). The eastbound and westbound portions of the roadway east of the intersection were divided by a 3.2 m (10.5 ft) wide grass median. Speed was regulated by a posted limit of 72 km/h (45 mph). West of the intersection, the eastbound portion consisted of a 3.7 m (12 ft) wide left lane supported by a 0.7 m (2.2 ft) wide shoulder and a 3.8 m (12.5 ft) wide right lane supported by a 1.3 m (4.3 ft) wide shoulder. There was also a right-turn-only lane, which departed the south roadway edge and transitioned into an entrance interchange for the limited access roadway prior to the intersection. East of the intersection, the east/west roadway was divided by a 1.2 (4 ft) wide raised concrete median. The left eastbound lane was 3.5 m (11.5 ft) wide with a 0.9 m (3 ft) wide median shoulder, while the right lane was 3.7 m (12 ft) wide and supported by a 3.4 (11 ft) wide north shoulder. A concrete barrier provided roadside departure protection along the south edge of the overpass, which transitioned to a guardrail that wrapped around the edge of the southeast intersection quadrant.

The Dodge was approaching the intersection in the 4.5 m (14.8 ft) wide left lane of the southbound one-way exit ramp from the limited access roadway. Speed on the limited access roadway was regulated by a posted limit of 113 km/h (70 mph). The exit-ramp roadway curved sharp left immediately prior to the intersection, and had an uphill slope of 4.7%. A Crash Diagram is included on page 23 of this technical report.

Pre-Crash

A local emergency response system received an emergent call regarding a 53-year-old male with severe abdominal pain. Subsequently, the parent ambulance agency was dispatched to answer the request. The ambulance agency responded by sending a Basic Life Support (BLS) ambulance to the scene, staffed by the 33-year-old male driver and two 23-year-old male EMS crewmembers. The driver had begun his shift that morning, and since had responded to a couple of previous EMS requests throughout the day, offset by rest and relaxation at the base of operations. The crewmembers, including an Emergency Medical Technician (EMT) and an observer, also had both been on duty for a majority of the day and had responded to the previous EMS requests with offset rest and relaxation.

The ambulance arrived at the location of the request and was presented with the 53-year-old obese male patient who was experiencing a sudden onset of severe abdominal pain. According to his medical records, the patient suffered from an array of medical conditions including obesity, diabetes, anemia, hypertension, musculoskeletal disorder, pulmonary disease, renal disease, deep vein thrombosis, and myocardial infarction. Due to his present illness, his family was requesting ambulance transport to a local hospital for evaluation and treatment.

After a brief physical exam, the EMT suspected that the patient was suffering a possible abdominal aortic aneurysm (AAA) and radioed the emergency response system to request immediate Advanced Life Support (ALS) assistance in treating the patient. The two crewmembers then moved the patient to the stretcher and into the ambulance as quickly as possible, while the driver assisted the patient's 53-year-old female spouse to the front right seating position. Once all five were situated within the vehicle, the ambulance began an emergency mode transport to the local hospital located approximately 64 km (40 mi) away.

The emergency response system had acknowledged the EMT's request and dispatched an ALS ambulance to intercept with the BLS ambulance while it was en route to the hospital. These two vehicles met roadside and the 50-year-old male Paramedic entered the BLS ambulance with his ALS equipment/supplies. The ambulance then resumed its emergency mode transport to the local hospital. The 50-year-old male Paramedic was seated in the middle of the left-facing bench seat on the right side of the patient compartment. The 23-year-old male observer was seated in the rear-facing "Captain's Chair" forward of the stretcher, while the 23-year-old male EMT was seated in the right-facing "CPR seat" on the left side of the patient compartment. The patient was lying supine on the stretcher, which was anchored longitudinally to the floor within the central area of the patient compartment. Seated within the vehicle's cab were the 33-year-old male driver and the 53-year-old female front right passenger.

After traveling approximately 58 km (36 mi), the ambulance approached the intersection in the left lane. Due to the emergency mode of its operation, traffic in the eastbound lanes moved right and came to controlled stops within the right lane and south shoulder.

The ambulance driver noted the uncontrolled status of the intersection, but visualized the traffic that had moved right and/or stopped in all apparent directions to provide him with the right of way. Accordingly, he believed that he had achieved control of the intersection and subsequently maintained eastbound travel through the intersection.

The Dodge had exited the limited access roadway and was traveling in the left lane of the southbound one-way roadway on approach to the same intersection. The driver of the Dodge indicated that he had observed the controlled status of the intersection for his direction of travel and proceeded to execute a left turn into the eastbound portion of the east/west roadway. The driver reported during the SCI interview that he did not see the ambulance or its flashing lights, nor did he hear its audible siren, prior to the crash. The driver of the ambulance reported during the SCI interview that he saw the Dodge immediately prior to impact and provided right steering input in an attempt to avoid a crash.

Crash

The first event occurred when the front of the Dodge contacted the left side of the ambulance within the forward half of the patient compartment module, aft of the cab. The point of impact was approximately 7 m (23 ft) west of the westbound lanes' intersection stop bar. Corresponding resultant directions of force were within the 9 o'clock sector for the ambulance and 2 o'clock sector for the Dodge. This resulted in minor severity sideswiping damage to the left plane of the ambulance. Minor severity damage was also sustained by the front right corner of the Dodge.

The ambulance driver's pre-impact right steering input redirected the ambulance toward the southeast intersection quadrant. To avoid a right roadside departure, the ambulance driver aggressively steered the vehicle left. This steering input redirected the vehicle northeast, and the ambulance approached the raised concrete median. Recognizing his over-correction, the driver again steered the vehicle right in an attempt to maintain the travel lanes. This quick steering input, coupled with the laden vehicle's combined weight and the wet roadway surface, resulted in a loss of traction at the rear axle positions and induced a clockwise (CW) rotation to the ambulance about its vertical axis.

As the vehicle maintained its eastbound trajectory in a CW yaw, the left rear axle position contacted the south curb of the raised concrete median (Event 2). Evidence of this contact consisted of gouging and metallic abrasions on the corner aspect of the curb surface on the overpass at a distance located 48 m (157.5 ft) east of the westbound lanes' intersection stop bar. An instability was created due to the lateral force load on the left side tires with respect to the vehicle's high center of gravity, which initiated a left-side leading rollover (Event 3). The ambulance completed a one-quarter turn trip-over about its longitudinal axis as the vehicle's left plane contacted the roadway surface and median.

An area of longitudinal gouging, metallic abrasions, and paint transfer was present on the median surface at a distance 54-56 cm (177-184 ft) east of the westbound lanes' intersection stop bar to evidence the ambulance's trajectory. The ambulance slid to rest on its left plane after a total uninterrupted roll distance of approximately 15-23 m (50-75 ft), as estimated by the ambulance's crewmembers during respective SCI interviews and discernible evidence at the scene.

Post-Crash

The driver retrieved the mobile radio's microphone and contacted the emergency response system to provide notification of the crash. Subsequently, local police, fire department, and EMS personnel responded to the scene. The 50-year-old male Paramedic was able to stand up and exit the patient compartment of the ambulance without assistance. He was followed by the 23-year-old male observer, who also exited the vehicle without assistance.

During the crash sequence, the combined forces associated with the obese patient's mass and the lateral impact resulted in the slight left lateral displacement and right rotation of the stretcher (with respect to its orientation within the patient compartment) out of its forward antler bracket. As a result, the stretcher was out of position when the ambulance came to rest on its left side, with the restrained patient lying face-down on the left-side cabinetry and on top of the EMT's legs with the stretcher partially on top of him. Accordingly, the patient remained restrained to the stretcher by its multi-point harness system and was unable to exit the vehicle due to his size, medical condition, and anatomical positioning. Furthermore, the displaced patient and stretcher resting on the EMT's legs prevented the EMT from exiting the vehicle, despite the fact that he was not mechanically entrapped as a result of patient compartment intrusion or deformation.

Removal of the patient from the overturned ambulance took emergency response personnel approximately 30 minutes, after which he was transported to the local hospital via a ground ambulance. The front right passenger was removed from the vehicle through the operational right front door and transported to the local hospital via a ground ambulance. After removal of the front right passenger, the driver was assisted from the vehicle through the right front door. All four of the EMS crewmembers, inclusive of the driver, EMT, observer, and Paramedic, were transported via ground ambulances to the local hospital for evaluation and treatment. The ambulance was towed from scene to the parent ambulance agency's base operations facility, where it was located for this SCI investigation. The Dodge was driven from scene by its owner.

2001 FORD F350 / MCCOY MILLER TYPE I AMBULANCE

Description

The 2001 Ford F350 chassis was manufactured in March 2001 and identified by the Vehicle Identification Number (VIN): 1FDWF37F61Exxxxxx. A placard confirmed that the vehicle conformed to all applicable Federal Motor Vehicle Safety Standards (FMVSS) in effect as of its date of manufacture. The chassis was a 4x4-drive axle platform with a dual-wheel rear axle. It was powered by a 7.3 liter, V-8 diesel engine linked to a 4-speed automatic transmission.

The chassis had a 422 cm (166 in) wheelbase and 4-wheel power-assisted hydraulic disc brakes with anti-lock. At the time of the SCI inspection (**Figure 3**), the vehicle's odometer reading was 160,880 km (99,966 mi). The vehicle manufacturer's recommended tire size was LT235/85R16, with recommended cold tire pressures of 400 kPa (58 PSI) front and 448 kPa (65 PSI) rear. During an interview, the ambulance agency's fleet manager reported that all six tires were replaced the previous year at the same time. Thus, at time of the SCI inspection, the vehicle was equipped with Goodyear Wrangler tires of the manufacturer's recommended size at all six axle positions, mounted on OEM steel wheels. All six tires had matching Tire Identification Numbers (TIN): MDOR Y5JV 0310. Specific tire data at the time of SCI inspection was as follows:



Figure 3: Front left oblique view of the 2001 Ford F350 / McCoy Miller Type I ambulance.

Position	Measured Pressure	Measured Tread Depth	Restriction	Damage
LF	538 kPa (78 PSI)	4 mm (5/32 in)	No	None
LR inner	517 kPa (75 PSI)	5 mm (6/32 in)	No	None
LR outer	Flat	6 mm (7/32 in)	No	Wheel rim abrasions
RR outer	345 kPa (50 PSI)	6 mm (7/32 in)	No	None
RR inner	448 kPa (65 PSI)	6 mm (7/32 in)	No	None
RF	517 kPa (75 PSI)	5 mm (6/32 in)	No	None

The interior of Ford's cab was configured for the seating of two occupants (**Figure 4**). Both were forward-facing bucket seats with manual seat track and seatback recline adjustments, and featured 3-point lap and shoulder safety belt systems for manual restraint. Head restraints were integrated into the seatbacks. A frontal air bag system provided supplemental restraint. There was a center console with an array of switches and communications equipment related to the ambulance's emergency response and operations activities between the two front seats.



Figure 4: Interior view of the Ford chassis' cab.

McCoy Miller Type I Ambulance

The Ford chassis was completed as a Type I - Class 2 Certified “Star of Life” ambulance during secondary manufacturing in September 2001. This consisted of the affixation to the Ford chassis of the McCoy Miller patient compartment module and installation of emergency services operational equipment such as warning lights, sirens, and radio communications. A placard confirmed that the McCoy Miller Type I ambulance conformed to Federal Specifications KKK-A-1822 in effect on its date of manufacture. This refers to the United States General Services Administration’s (GSA) standard for minimum specifications, test parameters, and criteria for design, performance, equipment, and appearance of ambulances in order to display the six-pointed blue star with Rod of Asclepius (Star of Life).

Patient Compartment Module

The McCoy Miller patient compartment module had overall dimensions length x width x height of 370 x 228 x 218 cm (145.7 x 89.8 x 85.8 in). There were six exterior compartments (three on both side planes) and three occupant access doors (one right, two rear). The exterior compartments served for the storage of and curbside access to large emergency medical equipment and supplies, such as backboards, stair-chairs, trauma dressing kits, splints, oxygen cylinders, and roadside safety/vehicle equipment. The 165 cm (65 in) tall by 68 cm (26.8 in) doublewide rear doors served for the loading and unloading of the stretcher, as well as entry/exit for the crew. A 180 cm (71 in) tall by 81 cm (32 in) wide right side door allowed further access to the module’s interior. Due to the location of the ambulance inside the parent agency’s garage at their base of operations, an image depicting the overall patient compartment module could not be obtained. An exemplar is depicted in **Figure 5** for visual reference.



Figure 5: Right rear oblique view of an exemplar Ford F350/McCoy Miller Type I-Class 2 ambulance.

The interior of the patient compartment module served as a mobile emergency room for the treatment of emergent medical conditions in a pre-hospital environment. It was configured for the seating of up to five crewmembers surrounding a centralized stretcher for the patient, with numerous wall-mounted cabinets, shelves, and countertops for the storage of medical equipment and supplies. It should be noted that at the time of the SCI inspection, all equipment and supplies had already been removed from the vehicle by the parent ambulance agency (**Figure 6**); however, inspection of another of the agency’s ambulances still in service served for exemplar purposes (**Figure 7**).



Figure 6: Interior of the ambulance's patient compartment module.



Figure 7: Interior of an exemplar patient compartment module.

On the left side of the patient compartment were seven storage compartments and two countertops, with an integrated seating position. The forward aspect, adjacent to the bulkhead, consisted of a large countertop, a switch panel with lighting and climate controls, and a wide storage compartment near the ceiling. Aft of the large countertop was a 60 cm (23.5 in) gap where the “CPR seat” was located. This seating position is so-named as its location within the chest area of the patient, with respect to the stretcher, places its occupant in an optimal location to perform cardiopulmonary resuscitation (CPR) on the patient. The seat consisted of a 53 cm (21 in) square seatback mounted to the wall with a 53 cm (21 in) wide by 27 cm (10.6 in) deep seat cushion. A wall-mounted lap belt was available for manual restraint of the occupant. Aft of the CPR seat was an array of six storage cabinets and a countertop shelf. Various medical supplies filled the storage cabinets, while an Automated External Defibrillator (AED) capable of Electrocardiograph (ECG) monitoring was located on the countertop.

At the forward aspect of the ambulance was a stack of storage cabinets, cab/module pass-through, and the “Captain’s Chair.” This position provides seating for one occupant and is so-named as its location near the module’s lighting and climate controls, as well as proximity to the cab and rear-facing overview of the stretcher, is frequently the location of the occupant providing administrative leadership for the crew. The seat itself consisted of a box-mounted 48 cm (19 in) wide by 52 cm (20.5 in) deep seat cushion with 48 cm (19 in) wide by 78 cm (31 in) tall seatback. A lap belt was available for manual restraint of the occupant.

Immediately to the right of the seatback was a 32 cm (12.6 in) wide by 39 cm (15.3 in) tall pass-through to the cab, which enabled visual and verbal communication between the driver and crew. Adjacent to the right wall was a stack of four cabinets for the storage of medical equipment bags and linen, with the heating, ventilation, and air-conditioning (HVAC) system near the ceiling. The right occupant access door occupied the forward aspect of the right plane, adjacent to the bulkhead’s stack of storage cabinets.

Aft of the door, and extending the full 196 cm (77.2 in) length to the rear, was the bench seat and two overhead storage compartments. The bench seat consisted of two 95 cm (37.4 in) wide by 36 cm (14.2 in) deep seat cushions with a 145 cm (57 in) wide by 36 cm (14.2 in) tall wall-mounted seatback. Three wall-mounted lap belts were available for manual occupant restraint.

Vehicle Weight/Payload

The Ford chassis was placarded by its manufacturer with a Gross Vehicle Weight Rating (GVWR) of 5,670 kg (12,500 lb). This was distributed as Gross Axle Weight Ratings (GAWR) of 2,200 kg (4,850 lb) front and 3,901 kg (8,600 lb) rear. A vehicle weight/payload certification sticker was located on the interior surface of the forward most exterior compartment door, placarded by the manufacturer of the McCoy Miller ambulance body. It declared that the curb weight of the overall vehicle after secondary manufacturing was 4,688 kg (10,334 lb). The curb weight at the axle locations was 2,102 kg (4,634 lb) in front and 2,586 kg (5,700 lb) in rear. Actual vehicle payload capacity was listed at 981 kg (2,166 lb).

The SCI investigation included the inspection of another of the parent ambulance agency's BLS vehicles for exemplar purposes. Based on this exemplar inspection, the estimated combined weight of the EMS equipment and supplies on-board the involved ambulance at the time of the crash was a minimum of 408 kg (900 lb). Information obtained during SCI interviews and from medical records enabled the SCI Investigator to calculate that the combined weight of the six occupants was 692 kg (1,525 lb). Thus, the total calculated payload of the laden ambulance at the time of the crash was 1,100 kg (2,425 lb). This exceeded the ambulance's available payload capacity by at least 119 kg (262 lb).

Exterior Damage

Damage to the exterior of the ambulance from the multiple event crash was limited to the left plane and consisted of abrasions and minor deformation. Direct contact from the Event 1 impact began 18 cm (7 in) aft of the leading edge of the patient compartment module on the left plane and extended 168 cm (66.2 in) rearward to 25 cm (9.8 in) forward of the left rear axle (**Figure 8**). The induced damage length shared the same measurements. Damage to the left plane from the first event impact consisted of slight lateral crush to the body/structure of the patient compartment module, with longitudinal sideswiping abrasions. The doors of the two forward exterior compartments of the ambulance, which were located within the damage pattern, were jammed shut by the lateral deformation.



Figure 8: Event 1 impact damage on the left plane of the McCoy Miller patient compartment module.

It should be noted that the forward most compartment's door was forced open post-crash by the ambulance agency's fleet manager for retrieval of the large on-board oxygen cylinder, and could not be closed due to deformation. A residual crush profile was measured on the left plane with a combined direct and induced damage length of 168 cm (66.2 in). Centered within the damage pattern at a height of 80 cm (31.5 in) above ground level, the profile consisted of the following measurements: C1–C2 = 0 cm (0 in), C3–C4 = 1 cm (0.5 in), and C5–C6 = 0 cm (0 in). Maximum crush was 1 cm (0.5 in). The Collision Deformation Classification (CDC) assigned to the ambulance, based on the SAE J224 MAR80 Recommended Practice definitions for a pickup truck of the same chassis type, was 10LBMS1.

Damage to the ambulance from the Event 2 curbstrike was located solely on the left rear wheel/outboard tire. The CDC assigned for Event 2 was 09LBWN1.

Exterior damage associated with the Event 3 rollover extended across the entire left plane. The left front fender was buckled and deformed right laterally with surface abrasions. The left side mirror was deformed right laterally at its pillar-mount, and the mirror glazing was out of place. On the exterior of the patient compartment module, there were heavy abrasions to the forward corner aspect and left roof side rail. The left aspect of the large emergency lights' colored lens, located on the forward plane of the module above the cab, was disintegrated. At the upper rear corner aspect of the patient compartment's left plane was an area of distinct direct contact



Figure 9: Rollover damage to the left plane of the ambulance.

damage. This area measured 72 cm (28.3 in) vertically and extended forward 76 cm (30 in) along the roof side rail from the upper rear corner. Maximum crush measured 3 cm (1.2 in) within this damage pattern on the roof side rail. An area of deformation at the upper rear corner of the patient compartment module was attributed to contact with the median curb on the overpass during the rollover sequence. The CDC assigned to the ambulance for the Event 3 damage pattern, based on a pickup truck of the same chassis type, was 00LDAO1 (**Figure 9**).

Event Data Recorder

The Ford chassis was equipped with an Air bag Control Module (ACM) mounted under the instrument panel in the center tunnel. The ACM had EDR capabilities to measure and record a longitudinal crash pulse with vehicle velocity change (delta-V) data points. The SCI Investigator attempted to image the EDR data using Bosch Crash Data Retrieval (CDR) hardware with software version 4.1.2. The EDR could only be imaged by the CDR software via the Diagnostic Link Connector (DLC) under the left instrument panel, below the vehicle's steering column.

Initial attempts were unsuccessful and produced error messages concerning an inability of the software to communicate with the ACM as the SCI Investigator experienced varying levels of electrical power fluctuations due to the extreme amperage demand of the ambulance's complex electrical system. The SCI Investigator then isolated the ambulance body's electrical system, including the emergency lights and power inverters, from the vehicle chassis' electrical system by utilizing the master disconnect switch installed during secondary manufacturing. Subsequent attempts to image the EDR resulted in successful "Pass 1" readings of the data by the software; however, the software produced an error message indicating an inability to communicate with the module during "Pass 2". This outcome was repeated consistently during multiple attempts to image the data. Ultimately, the SCI Investigator was unsuccessful in imaging the Ford's EDR.

Interior Damage

Inspection of the interior of the Ford chassis' cab was unremarkable. There was no intrusion or interior damage associated with the exterior crash forces. The windshield and left front glazing were intact and undamaged; however, the right front window glazing was disintegrated. It should be noted that the ambulance agency's fleet manager reported during an interview that this damage occurred post-crash during towing and recovery efforts, and thus was not crash related.

There were limited contact points identified during the inspection of the cab. The majority of these contacts consisted of dirty boot/sneaker imprints and impressions on the right lateral surfaces of the seat cushions and seatbacks. These contacts were the result of egress activities post-crash. The only identifiable crash-related contact was located on the interior surface of the left front window glazing, which consisted of an imprint/body oil transfer. This contact was attributable to the left aspect of the driver's head.

Interior damage to the patient compartment was sustained by the wall-mounted cabinetry on the left side. Seven of the fourteen sliding plexi-glass storage cabinet doors were fractured as a result of occupant contact and unsecured interior cargo contact during the crash, as well as egress of the occupants post-crash (**Figure 10**). During the rollover sequence, the unrestrained bench seat occupant initiated a forward trajectory with respect to his left-facing orientation, traveled over the stretcher, and contacted the storage cabinets immediately aft of the CPR seat. The force of this contact fractured the plexi-glass doors and loaded the plywood shelves, which resulted in the slight [< 1 cm (< 0.4 in)] separation of the angular joint of the shelf adjacent to the CPR seat. The remaining interior planes showed no evidence of damage or occupant contact.



Figure 10: Cabinetry damage to left side of patient compartment interior.

Manual Restraint Systems

The cab of the Ford chassis was equipped with manual restraint systems for both seating positions. Each was a 3-point lap and shoulder safety belt system that consisted of continuous loop webbing with a sliding latch plate, and was height-adjustable at its respective B-pillar-mounted D-ring anchor position. The driver's safety belt retracted onto an Emergency Locking Retractor (ELR), while the front right passenger's safety belt retracted onto an ELR/Automatic Locking Retractor (ALR). At the time of the SCI inspection, both belt systems were intact, operational, and exhibited evidence of significant historical use. Both D-ring anchors were adjusted to their full-down positions. Frictional abrasions from the webbing present on both sliding latch plates confirmed restraint usage by both occupants at the time of the crash.

The patient compartment of the ambulance was equipped with lap belts at all five seating positions. All manual restraint systems within the patient compartment utilized continuous loop webbing. The lap belts for the CPR seat, Captain's chair, and bench seat all retracted onto ELRs mounted to the patient compartment wall (CPR and bench seats) and box-mount (Captain's chair). At the time of the SCI inspection, the safety belt systems within the patient compartment of the ambulance displayed minor to no evidence of historical use. Restraint usage by any of the crewmembers could not be confirmed or disputed based solely on the post-crash conditions of the safety belt systems.

Supplemental Restraint Systems

The cab of the Ford chassis was equipped with a frontal air bag system for supplemental restraint. This system consisted of dual-stage air bags available for the driver and front right passenger, mounted within the steering wheel hub and top instrument panel. Both air bags were original manufacturer installed and had not required any service/maintenance prior to the crash. The lateral impact (Event 1) and rollover (Event 2) did not achieve a longitudinal crash pulse sufficient enough to deploy the frontal air bag system.

Patient Stretcher

The patient stretcher was a POWERFlexx+ Power Ambulance Cot that was manufactured by Ferno-Washington Incorporated, serial number: 10N-176613. It was of all-metal construction with tubular legs aligned in an X-frame that featured power raise/lower capabilities (**Figure 11**). Electrical power was supplied by an on-board 24V lead acid DC battery pack, which could be charged automatically via the Integrated Charging System (ICS) while locked into position within the patient compartment of the ambulance or manually via an external 120V household connection.



Figure 11: The POWERFlexx+ stretcher in its raised position during the SCI inspection.

A placard declared that the overall load capacity limit of the stretcher was 318 kg (700 lb) when the legs were extended or 454 kg (1,000 lb) when the legs were folded. Dimensions of the mattress were 40 cm (15.8 in) wide and 200 cm (78.7 in) long, while the overall dimensions of the stretcher were 57 cm (22.4 in) wide and 215 cm (84.6 in) long. The mattress featured torso and leg platform angular adjustments via manually controlled hydraulic cylinders.

The Ferno stretcher was equipped with a multi-point harness system for manual restraint of its occupant (patient). This multi-point harness system included a lateral leg strap, lateral lap strap, and shoulder/chest harness, in which a pair of shoulder straps buckled into a chest strap. The safety belt webbing was continuous loop, and all straps included locking latch plates for length adjustment. The leg, lap, chest, and shoulder straps were 102 cm (40 in), 127 cm (50 in), 198 cm (78 in), and 112 cm (44 in) in length, respectively.

At the time of the crash, the lateral leg, lap, and chest straps utilized 30 cm (12 in) belt extensions to accommodate the obese patient. Exact adjusted length of the straps at the time of the crash is unknown; however, the EMS crew reported during the interview that the patient was “snugly” restrained using all available multi-point harness system straps. Although heavy historical use masked loading evidence, the post-crash positioning of the patient and emergency services observations confirmed complete restraint usage.

Stretcher Anchoring System

The stretcher was secured in place within the patient compartment module via a Model 6370 Cot Fastener System. It was manufactured by Stryker in June 2006, as identified by the manufacturer’s S/N: 060639403. The system consisted of a forward antler bracket and rearward locking-clamp mechanism. The antler bracket cradled the forward portion (location of the patient’s head area) of the stretcher’s frame, while the vertically-oriented locking mechanism clamped around a pin protruding from the stretcher’s lower frame rail. Combined, these two components served to restrict the lateral and longitudinal movement of the stretcher.

During the crash sequence, lateral and non-horizontal forces induced lateral and rotational movement to the stretcher (with respect to the patient compartment module’s floor). Due to the location of the locking-clamp mechanism at the left rear corner of the patient compartment module affixed to the right aspect of the stretcher (with respect to its orientation), the mass of the stretcher, aforementioned crash forces, and mass of the obese patient induced a negative moment of inertia about the longitudinal axis of the locking clamp. The vertical orientation of the clamp translated an equivalent perpendicular normal force through the anchor pin to the stretcher’s frame to restrict the lateral movement of the stretcher. Accordingly, the forces translated to the forward aspect (head area) of the stretcher, which rotated out of the antler bracket. This resulted in the right lateral rotation (with respect to the stretcher occupants’ orientation) toward the left wall cabinetry within the patient compartment.

As the ambulance completed the rollover and came to rest, the stretcher rotated slightly out of position. Consequently, the restrained obese patient came to rest lying on his right anterior side against the left wall cabinetry within the ambulance's interior and on the EMT's legs, with the stretcher in contact with his left posterior side. **Figure 12** depicts the locking-clamp mechanism within the Ford at the time of the SCI inspection; **Figure 13** depicts the forward antler bracket.



Figure 12: Locking-clamp mechanism of the Stryker Cot Fastener System at the time of the SCI inspection.



Figure 13: Forward antler bracket of the Stryker Cot Fastener System within the Ford.

2001 FORD F350 / MCCOY MILLER TYPE I AMBULANCE OCCUPANTS

Driver Demographics

Age / Sex:	33 years / Male
Height:	170 cm (67 in)
Weight:	59 kg (130 lbs)
Eyewear:	None
Seat Type:	Bucket
Seat Track Position:	Between forward most and middle
Manual Restraint Usage:	3-point lap and shoulder safety belt
Usage Source:	Vehicle inspection
Air Bags:	None deployed
Alcohol/Drug Involvement:	None
Egress from Vehicle:	Exited vehicle with assistance
Transport from Scene:	Ground ambulance to a local hospital
Medical Treatment:	Treated and released on the same day

Driver Injuries

Inj No.	Injury	AIS 2005/08	Injury Source	Confidence Level
1	Concussion, NFS	161000.1,0	Left front glazing	Certain
2	Left scalp contusion	110402.1,2	Left front glazing	Certain

Source: Interview (same person)

Driver Kinematics

The 33-year-old male driver was seated in the bucket seat. He was restrained snugly by the manual 3-point lap and shoulder safety belt system. The seat track was adjusted to a position between forward most and mid-track.

The driver initiated a slight left lateral trajectory in response to the first impact event. He contacted and loaded the belt webbing as the ELR engaged, keeping his body in position. As the vehicle began to roll left laterally, he maintained contact with the safety belt webbing. His left flank contacted the armrest on the left front door panel. The driver's head contacted the left front glazing, resulting in a scalp contusion and concussion.

The driver remained restrained throughout the crash sequence and came to rest within the driver's seat, with his left flank in contact with the left front door panel. He was assisted from the vehicle through the right front door by emergency services personnel and transported to a local hospital. The driver was treated and released on the same day.

Front Right Passenger Demographics

Age / Sex:	53-years / Female
Height:	163 cm (64 in)
Weight:	70 kg (155 lb)
Eyewear:	Unknown
Seat Type:	Bucket
Seat Track Position:	Rearmost
Manual Restraint Usage:	3-point lap and shoulder safety belt
Usage Source:	Vehicle inspection
Air Bags:	None deployed
Alcohol/Drug Involvement:	None
Egress from Vehicle:	Removed from vehicle with assistance
Transport from Scene:	Ground ambulance to a local hospital
Medical Treatment:	Treated and released on the same day

Front Right Passenger Injuries

Inj No.	Injury	AIS 2005/08	Injury Source	Confidence Level
N/A	None	N/A	N/A	N/A

Source: Interview (surrogate: son)

Front Right Passenger Kinematics

The 53-year-old female front right passenger was seated in the forward-facing bucket seat, which was adjusted to its rearmost track position. She was restrained by the manual 3-point lap and shoulder safety belt system.

The front right passenger initiated a slight left lateral trajectory in response to the first impact event. She contacted and loaded the belt webbing as the ELR engaged, keeping her body in position.

As the vehicle began to roll left laterally, she maintained contact with the safety belt webbing. Her left flank contacted the armrest attached to the left aspect of the seatback, though she remained within the seat.

The front right passenger remained restrained throughout the crash sequence and came to rest within the front right seat. She was assisted from the vehicle through the right front door by emergency services personnel and transported to a local hospital, where she was evaluated and released on the same day without injury.

CPR Seat Occupant Demographics

Age / Sex: 23 years / Male
 Height: 170 cm (67 in)
 Weight: 122 kg (270 lb)
 Eyewear: None
 Seat Type: Other seat type (specify: integrated into wall-mounted cabinets)
 Seat Track Position: Not adjustable
 Manual Restraint Usage: Lap belt
 Usage Source: Interview
 Air Bags: None available
 Alcohol/Drug Involvement: None
 Egress from Vehicle: Exited vehicle with assistance
 Transport from Scene: Ground ambulance to a local hospital
 Medical Treatment: Treated and released on the same day

CPR Seat Occupant Injuries

Inj No.	Injury	AIS 2005/08	Injury Source	Confidence Level
1	Compartment syndrome to left lower leg, no bone/muscle damage	812005.2,2	Stretcher frame	Certain
2	Compartment syndrome to right lower leg, no bone/muscle damage	812005.2,1	Stretcher frame	Certain
3	Bilateral lower leg contusions	810402.1,3	Stretcher frame	Certain

Source: Interview (same person)

CPR Seat Occupant Kinematics

The 23-year-old male EMT was seated upright in the right-facing CPR seat on the left side of the patient compartment module. He reported to the SCI Investigator during the interview that he was restrained by the wall-mounted lap belt. The male EMT initiated a rearward trajectory with respect to his right-facing orientation as a result of the first event impact. His back contacted the wall-mounted seatback, and he remained within the CPR seat. Longitudinal forces associated with the lateral vehicle impact did not have sufficient magnitude to affect his trajectory.

As the vehicle initiated the rollover sequence, the EMT remained restrained within the CPR seat. His back loaded the seatback as the ambulance came to rest on its left side. The force of gravity, combined with the patient's body mass, resulted in the slight right lateral roll of the stretcher with respect to its orientation within the patient compartment. Subsequently, the stretcher's proximity to the left side of the patient compartment and CPR seat resulted in occupant-to-occupant interaction as the right flank of the patient contacted and came to rest on the male EMT's lower legs. The side rail of the stretcher also contacted the EMT's lower legs.

The combination of the patient's body mass and corresponding positioning of the stretcher effectively pinned the EMT's legs against the forward edge of the CPR seat. Thus, although he did not sustain direct crash-related injury or entrapment, he was unable to exit the ambulance due to the restrained obese patient and stretcher resting on his lower legs.

Subsequently, the EMT remained in position within the CPR seat until emergency response personnel removed the patient and stretcher from the ambulance, which ultimately resulted in the injuries to his lower legs. He was then able to exit the vehicle without assistance. The male EMT was transported via ground ambulance to a local hospital, where he was treated and released on the same day.

Captain's Chair Occupant Demographics

Age / Sex:	23 years / Male
Height:	182 cm (71.7 in)
Weight:	116 kg (255.7 lb)
Eyewear:	None
Seat Type:	Box mounted
Seat Track Position:	Not adjustable
Manual Restraint Usage:	None
Usage Source:	Interview
Air Bags:	None available
Alcohol/Drug Involvement:	None
Egress from Vehicle:	Exited vehicle without assistance
Transport from Scene:	Ground ambulance to a local hospital
Medical Treatment:	Treated and released on the same day

Captain's Chair Occupant Injuries

Inj No.	Injury	AIS 2005/08	Injury Source	Confidence Level
1	Right shoulder abrasion	710202.1,1	Left side cabinetry	Certain

Source: Medical Records; Interview (same person)

Captain's Chair Occupant Kinematics

The 23-year-old male observer was seated within the rear-facing Captain's Chair. He did not utilize the lap belt for manual restraint. He was positioned upright in the non-adjustable seat with his back against the seatback.

At impact with the Dodge, the Captain's Chair occupant initiated a right lateral trajectory with respect to his positional orientation. The left side impact did not have a longitudinal crash pulse significant enough to affect the occupant's longitudinal kinematics. He remained within the Captain's Chair seating position as the vehicle maintained its forward trajectory.

The occupant continued his right lateral trajectory as the ambulance initiated and completed its rollover sequence. His right shoulder contacted the left side cabinetry within the patient compartment module. This contact resulted in an abrasion to the occupant's right shoulder.

The Captain's Chair occupant came to rest within the seating position, lying with his right flank in contact with the left side cabinetry. Post-crash, he exited the ambulance through the rear doors without assistance. He was transported from the scene to a local hospital by ground ambulance, where he was evaluated and released on the same day.

Bench Seat Occupant Demographics

Age / Sex:	50 years / Male
Height:	175 cm (68.9 in)
Weight:	84 kg (185.2 lb)
Eyewear:	Unknown
Seat Type:	Bench
Seat Track Position:	Not adjustable
Manual Restraint Usage:	None
Usage Source:	Vehicle inspection
Air Bags:	None available
Alcohol/Drug Involvement:	None
Egress from Vehicle:	Exited vehicle without assistance
Transport from Scene:	Ground ambulance to a local hospital
Medical Treatment:	Treated and released on the same day

Bench Seat Occupant Injuries

Inj No.	Injury	AIS 2005/08	Injury Source	Confidence Level
1	Left shoulder strain	740402.1,2	Left side cabinetry	Certain
2	Small left occipital scalp hematoma	110402.1,6	Left side cabinetry	Certain
3	Lumbosacral strain	640678.1,8	Left side cabinetry	Certain

Source: Medical Records; Interview (surrogate: other occupants - crewmembers)

Bench Seat Occupant Kinematics

The 50-year-old male Paramedic bench seat occupant was seated within the middle area of the bench seat. He was not restrained by the manual lap belt. Prior to the crash, the Paramedic was involved in emergency medical care activities related to the treatment of the 53-year-old male patient.

At impact with the Dodge during the first event, the Paramedic initiated a forward trajectory with respect to his left-facing position. The longitudinal magnitude of the crash pulse was not sufficient enough for the Paramedic's mass to initiate a forward trajectory (to his right). As the vehicle maintained its trajectory and initiated the left lateral rollover, the Paramedic continued on his forward trajectory toward the left side interior of the patient compartment. His movement was then directed downward with respect to the force of gravity as the vehicle achieved one-quarter turn. He traveled over the patient and stretcher and contacted the left interior cabinetry. The force of this contact loaded the sliding plexi-glass doors of the cabinets and fractured them. His left shoulder loaded the plywood structure of the cabinets, resulting in left arm/shoulder pain.

The Paramedic's head also contacted the left side cabinetry, resulting in forehead pain. He came to rest lying on his left flank on the left cabinetry. Post-crash, the bench seat occupant immediately stood up and exited the vehicle without assistance. He was evaluated at scene and transported to a local hospital by emergency response personnel, and was treated and released on the same day.

Stretcher Occupant Demographics

Age / Sex:	53 years / Male
Height:	183 cm (72 in)
Weight:	240 kg (529.1 lb)
Eyewear:	None
Seat Type:	Other seat type (specify: EMS stretcher)
Seat Track Position:	Not adjustable
Manual Restraint Usage:	Multi-point harness system
Usage Source:	Vehicle inspection / Interview
Air Bags:	None available
Alcohol/Drug Involvement:	None
Egress from Vehicle:	Removed from vehicle by emergency services personnel
Transport from Scene:	Ground ambulance to a local hospital
Medical Treatment:	Transported to a local hospital, expired 1.5 hours after arrival

Stretcher Occupant Injuries

Inj No.	Injury	AIS 2005/08	Injury Source	Confidence Level
1	Right upper arm abrasion	710202.1,1	Left side cabinetry	Certain
2	Abrasion to the middle aspect of the abdomen with diffuse swelling	510202.1,7	Left side cabinetry	Certain
3	Abrasion to lower right leg (shin) and top of right foot	810202.1,1	Left side cabinetry	Certain

Source: Medical records; Interview (surrogate: son, other occupants - crewmembers)

Stretcher Occupant Kinematics

The 53-year-old obese male patient was positioned supine on the Ferno stretcher. He was restrained by the multi-point harness system using extension straps. Restraint usage was confirmed independently by all ambulance crewmembers during respective SCI interviews. The male patient initiated a right lateral trajectory with respect to his rear-facing orientation in response to the first event impact. His body movement was restrained by the multi-point harness system, and he remained supine on the stretcher.

As the ambulance began the left rollover sequence, the patient maintained a right lateral trajectory. His body mass combined with the forces of gravity and the rollover, inducing a right lateral rotation about the stretcher's longitudinal axis. This force was transferred from the stretcher's frame to the forward mounting bracket and rear locking mechanism. The forward wheels of the stretcher shifted within the mounting bracket and the stretcher rotated slightly about its longitudinal axis to its right. This movement was restricted at the rear aspect of the stretcher by the locking mechanism, and the forward aspect of the stretcher subsequently shifted from its secured position. As a result of this displacement, the occupant contacted the lower portion of the left wall cabinetry and the CPR seat occupant's lower legs.

The patient remained on the stretcher restrained by its multi-point harness system and came to rest lying in an anterior position, with the stretcher in contact with his posterior. This positioning, in conjunction with his pre-existing medical conditions and obesity, compromised his ability to achieve complete tidal exchange during his respiratory process. Emergency response personnel worked diligently to remove the patient from the overturned vehicle; however, their efforts were hindered by the combination of the patient's mass, the stretcher's slightly displaced positioning, and the cramped space within the patient compartment. Extrication of the patient from the overturned ambulance by emergency response personnel, despite the lack of entrapment by mechanical or intruded means, required approximately 30 minutes.

By the time the patient was extricated from the overturned vehicle, the duration of his positioning and its corresponding impediment on his breathing capabilities had diminished his respiratory response to agonal respirations. Subsequently, he became asystolic and spontaneous respirations ceased. Emergency response personnel immediately began CPR, advanced airway management, and advanced cardiac life support, and transported the patient to a local hospital.

The patient was resuscitated shortly after his arrival at the hospital's emergency department. As he was being prepared to be transferred to a different facility more adequately equipped to handle targeted care, the patient again became asystolic. Attempts to resuscitate were initiated by the hospital, but were unsuccessful. The documented time of death occurred 1.5 hours after his initial arrival at the hospital. Due to the patient's pre-existing medical conditions and at the request of his family, no autopsy was performed to confirm the reported cardiac-related cause of death or determine contributory crash-related injuries.

1997 DODGE RAM 2500

Description

The 1997 Dodge Ram 2500 was identified by the VIN: 1B7KF26D6VJxxxxxx. This 2-door pickup truck (**Figure 14**) was equipped with the Laramie level trim package and was powered by a 5.9 liter, inline 6-cylinder diesel engine linked to a 4-speed automatic transmission. The interior of the Dodge was configured for the seating of three occupants, with 3-point lap and shoulder safety belt systems for the outlying seating positions and a lap belt for the center position. The seatback of the center seat folded forward to serve as a center console/armrest. The manufacturer's recommended tire sizes and pressures remain unknown because no placard could be located on the vehicle. At the time of the SCI inspection, the Dodge was equipped with four Cooper Discoverer S/T tires of the manufacturer's recommended tire size LT265/75R16. Specific tire data included:



Figure 14: Left front oblique view of the Dodge.

Position	Measured Pressure	Measured Tread Depth	Restriction	Damage
LF	400 kPa (58 PSI)	6 mm (8/32 in)	No	None
LR	407 kPa (59 PSI)	6 mm (7/32 in)	No	None
RR	338 kPa (49 PSI)	4 mm (5/32 in)	No	None
RF	303 kPa (44 PSI)	8 mm (10/32 in)	No	Shallow cut in sidewall

Exterior Damage

The Dodge did not sustain disabling damage as a result of the crash, and its driver retained possession of the vehicle post-crash and drove it from the scene. The SCI Investigator contacted the Dodge's driver via telephone, and cooperation was established to inspect the vehicle near his place of employment. Damage from the Event 1 impact was minor, limited to the front right corner of the Dodge (**Figure 15**). This included the rearward deformation of the bumper corner's right aspect and proximal surrounding components. The right front headlight assembly was disintegrated, and the right front fender was deformed. There was minor direct contact on the forward aspect of the right front tire/wheel, which consisted of a shallow laceration of the outer layer of the tire's sidewall and the minor indentation of the leading edge of the wheel rim.



Figure 15: Right front oblique view of the Event 1 damage pattern to the Dodge.

Both the direct contact and induced damage to the frontal plane began 70 cm (27.5 in) right of center and extended 30 cm (11.8 in) to the right front bumper corner. A residual crush profile documented at mid-bumper level produced the following results: C1 - C5 = 0 cm (0 in), C6 = 19 cm (7.5 in). The CDC associated with this Event 1 damage pattern was 03FREE2.

Occupant Data

The Dodge was occupied by a 20-year-old male driver and an 18-year-old female front right passenger at the time of the crash. During the SCI interview, the driver reported that neither he nor his passenger was injured during the crash. They did not receive any medical treatment post-crash.

CRASH DIAGRAM

